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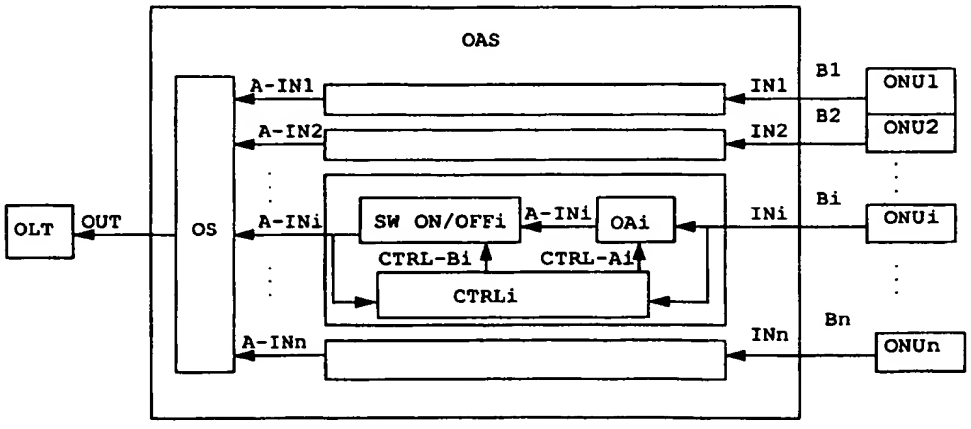
(54) Arrangement for amplifying and combining optical signals, and method for upstream transmission realised therewith

(57) The optical amplifier splitter arrangement is used in a tree-like optical network (APON) consisting of the cascade connection of dedicated branches, of the arrangement and of a common branch. The arrangement is coupled between a plurality of optical network users and an optical line terminator, via the dedicated branches and the common branch respectively. The network enables upstream transmission of information signals from the optical network users to the optical line terminator. The optical amplifier splitter arrangement includes for each branch of the dedicated branches :

- an optical amplifier to amplify an information signal with a gain value and to thereby generate an amplified information signal with a predetermined power level;
- an optical switch on/off coupled between the optical amplifier and an optical splitter to pass the amplified information signal when the information signal is present and to interrupt the branch when the information signal is not present. The optical splitter is included in the arrangement to combine all amplified information signals according to a multiple access technique and to thereby generate an outgoing optical signal for application to the optical line terminator.



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Description

The present invention relates to an optical amplifier splitter arrangement as described in the preamble of claim 1 and a method for upstream transmission realised thereby, used in a tree-like optical network to perform upstream transmission as described in the preamble of claim 10.

Such an optical amplifier splitter and such a method are already known in the art, e.g. from the article '*Network Design for the Information Superhighway*' written by P.W. France, J.H. Mackenzie and others, published by The European Institute for Communications and Networks in the book Proceedings volume 1 Papers on Broadband Superhighway wherein passive optical networks are described which use such a splitter and which realize such a method. These passive optical network systems are developped to meet the emerging superhighway requirements such as the capability to provide both existing narrowband and new broadband distributive and interactive services to serve both business and residential customers.

However serving business and residential customers requires a much higher splitting factor than provided by these known networks. A main problem in the realization of high splitting factors occurs during the upstream transmission. Indeed, due to this high splitting factor a high powerbudget must be overcome. The demanding optical powerbudget for transmission is supported by the implementation of optical amplifiers in the dedicated branches. However, due to the multiple access technique used at the optical splitter which combines the information signals, all these optical amplifiers contribute to an accumulation of ASE (amplified spontaneous emission) noise, even when the optical amplifier does not carry an information signal and as a result thereof, the ASE noise can reach such an amplitude that the transmitted signals are degraded.

An object of the present invention is to provide an optical amplifier splitter arrangement and a method such as the above known ones but which are suited for networks with high splitting factors, i.e. which ensure that the transmitted signals can not be degraded by the relatively high ASE noise.

According to the invention, this object is achieved by means of the optical amplifier splitter arrangement as described in claim 1, realizing the method as described in claim 10.

Indeed, since the branches which carry no information signal, are interrupted with the optical switches on/off, these branches can not contribute to the accumulation of ASE noise at the optical splitter.

A possible implementation of the control of the optical amplifier splitter arrangement is that for each branch the gain value of the optical amplifier and the optical switch on/off are controlled respectively by means of a first and second electrical control signal. This implementation is described in claim 2. The first electrical control signal is composed of gain setting data and gain tuning data. This gain tuning data is introduced to compensate deviations of the optical amplification due to e.g. sensitiveness with respect to temperature and time of the optical amplifier.

An additional characteristic feature of the present invention is that, as described in claim 3, the switch on/off is controlled by means of the second electrical control signal which results from the detection of the presence of an information signal on the according branch.

Another way of controlling the switch on/off is described in claim 4, and is based on the use, in an optical network using for upstream transmission a time division multiple access technique, of the detection of special grant information out of downstream information. The use of such special grant information to realize time division multiple access is well known in the art, e.g. from the publisched *European patent application with publication number EP-0 544 975* wherein a time slot management system is described which allows upstream transmission. The stream of station identities used therein is similar to the special grant information. In the implementation of claim 4 the second electrical control signal is determined by the detection of special grant information in downstream information.

Yet a further characteristic feature of the present invention is that, as described in claim 5, the gain setting data is determined by measuring the power of the information signal.

Another characteristic feature of the present invention is that, as described in claim 6, the gain tuning data is determined by measuring the power of the amplified information signal.

An alternative way to determine the gain tuning data is described in claim 7 and consists in using a memory means to memorize the value of the last measured power of an amplified signal and to use this value to control the gain tuning data for a following transmitted information signal.

Another way to determine the gain tuning data is described in claim 8, which introduces a power level unit to measure the power level of the outgoing optical signal to determine the gain tuning data for the branches carrying an information signal. In this way, instead of measuring the power for each dedicated branch, only one power measurement has to be performed which is less power consuming.

Still another characteristic feature is the integration of the optical splitter with all optical switches on/off in one optical switch, as described in claim 9.

The above mentioned and other objects and features of the invention will become more apparent and the invention itself will be best understood by referring to the following description of an embodiment taken in conjunction with the accompanying drawing.

First, the optical amplifier splitter arrangement OAS will be explained by means of a functional description of the blocks shown in the figure. Based on this description, implementation of the functional blocks in the fig-

ure will be obvious to a person skilled in the art.

The optical amplifier splitter arrangement OAS is used in a tree-like optical network consisting of the cascade connection of dedicated branches B1, B2, ..., Bi,...Bn and of the optical amplifier splitter arrangement OAS and of a common branch. The optical amplifier splitter arrangement OAS is coupled between a plurality of optical network users ONU1, ONU2, ..., ONUi, ..., ONUn and an optical line terminator OLT via the above mentioned dedicated branches and common branch respectively.

The optical amplifier splitter arrangement OAS includes for each branch e.g. Bi, of the dedicated branches B1, B2,..., Bi, ..., Bn two basic parts :

- an optical amplifier OAi coupled to the respective netwotk user ONUi of the optical network users ONU1, ONU2, ..., ONUi, ..., ONUn; and
- an optical switch on/off SW ON/OFFi coupled between the optical amplifier OAi and an optical splitter OS.

The optical splitter OS is coupled between all optical switches on/off SW ON/OFF1, SW ON/OFF2, ..., SW ON/OFFi, ..., SW ON/OFFn which are simular to the optical switch on/off SW ON/OFFi and the optical line terminator OLT.

The optical amplifier splitter arrangement OAS enables upstream transmission in the optical network of information signals IN1, IN2, ..., INi, ... , INn from the optical network users ONU1, ONU2, ..., ONUi, ..., ONUn to the optical line terminator OLT.

The principle working of the optical amplifier splitter OAS will be explained in the following paragraph with respect to a signal INi transmitted over a branch Bi, the working with respect to the other branches being identical.

The optical amplifier OAi amplifies INi with a gain value Gi (not shown) and generates thereby an amplified information signal A-INi with a predetermined power level.

The optical switch on/off SW ON/OFFi passes the amplified information signal A-INi when it is present, but interrupts the branch Bi when the amplified information signal A-INi is not present.

The optical splitter OS combines all amplified information signals A-IN1, A-IN2, ..., A-INi, ..., A-INn simular to the amplified information signal A-INi according to a multiple access technique and generates thereby an outgoing optical signal OUT for application to the optical line terminator OLT.

In this embodiment the working of the optical amplifier OAi and the optical switch on/off SW ON/OFFi of each branch Bi is controlled by means of control means CTRLi. The control means CTRLi is coupled to the OAi and the optical switch on/off SW ON/OFFi and controls :

- the gain value Gi by means of a first electrical control signal CTRL-Ai composed of gain setting data GSi (not shown) and gain tuning data GTi (not shown); and
- the switch on/off SW ON/OFFi by means of a second electrical control signal CTRL-Bi.

The gain setting data GSi, the gain tuning data GTi and the second electrical control signal CTRL-Bi can be determined in different ways. A few particular implementations to determine them are described in a functional way in the following paragraphs, but they are not shown in the figure to avoid overloading thereof.

To determine the second electrical control signal CTRL-Bi, for each branch Bi, the control means CTRLi further includes power detection means which via an optical tap draws off the information signal INi a small power part. The power detection means determines whether the information signal INi is present or is not present and determines the second electrical control signal CTRL-Bi as a result thereof.

To determine the gain setting data GSi, for each branch Bi, the control means CTRLi further includes power measuring means. The same optical tap as above is used and the power measuring means measures the power of the information signal INi and determines the gain setting data GSi based thereon.

It has to be noted here, that to ensure that the power measuring means has enough time to fulfil its function, an optical delay line (not shown) is coupled between the optical tap and the optical amplifier OAi. The optical delay line delays the information signal INi untill the optical amplifier OAi is adjusted.

To determine the gain tuning data GTi, for each branch Bi, the control means CTRLi further includes additional power measuring means. Via an additional optical tap, coupled between the optical switch on/off SW ON/OFFi and the optical splitter OS a small power part is drawn off the amplified information signal A-INi and the additional power measuring means measures the power of the amplified information signal A-INi and determines the gain tuning data GTi based thereon.

Furthermore it is noted that although for the optical amplifier OAi an erbium doped fibre amplifier is used, semiconductor optical amplifiers are very good candidates to use in this implementation because of their low switch-on time. It is also remarked that these semiconductor optical amplifiers can be used to integrate the functions of the optical amplifier OAi and of the optical switch on/off SW ON/OFFi.

An alternative implementation to determine the second electrical control signal CTRL-Bi is realised for optical networks where the optical splitter OS combines the amplified information signals A-IN1, A-IN2, ..., A-INi, ..., A-INn according to a time division multiple access technique. For such an optical network, the optical amplifier splitter arrangement OAS includes an optical network terminator NTOAM (not shown) for performing operation and maintenance functions. The NTOAM is coupled to the optical line terminator OLT, by means of also an additional optical tap, and to the control means

CTRLi. The additional optical tap draws off the downstream signals which are sent from the optical line terminator OLT to the optical network terminators ONU1, ONU2, ..., ONUi, ..., ONUn a small powerpart and provides this power fraction to the optical network terminator NTOAM which captures special grant information out of these downstream signals. According to the remark in the introduction, the use of special grant information to realize time division multiple access is well known in the art. With this special grant information, the optical network terminator NTOAM knows exactly when an information signal INi will be sent by an optical network user ONUi and when the information signal INi will be applied to the optical amplifier OAi. The special grant information is applied to the control means CTRLi which is now able to determine whether the information signal INi will be present or will not be present within a predetermined time interval and determines the second electrical control signal CTRL-Bi as a result thereof.

Still another alternative implementation to determine the gain tuning data GTi, for each branch Bi, is realised by including in the control means CTRLi, additional to measuring means to measure the power of an amplified information signal A-INi, also memory means to memorize the value of the measured power of the amplified signal. This value is used to determine the gain tuning data GTi for a following transmitted information signal INi.

Finally, it has to be remarked that an alternative way to determine the gain tuning data GTi, for each branch Bi, is realized with the implementation of one power level unit. The power level unit, included in the optical amplifier splitter arrangement OAS, is coupled between a control output of the optical splitter OS and the control means CTRLi associated with each branch Bi. The power level unit measures the power level of the outgoing optical signal OUT and provides the result thereof by means of electrical power level data to the control means CTRLi. The control means CTRLi is now able to determine the gain tuning data GTi if an information signal is present.

It has to be remarked that the optical splitter OS and all optical switches on/off SW ON/OFF1, SW ON/OFF2, ..., SW ON/OFFi, ..., SW ON/OFFn simular to the optical switch on/off SW ON/OFFi can be integrated in one optical switch.

Since it is obvious for a person skilled in the art how to realize the above alternative implementations, based on their functional description, these realizations are not described in further details.

It has also to be remarked that the outgoing optical signal OUT of the present optical amplifier splitter arrangement OAS has to be amplified in order to overcome a longe distance to the optical line terminator OLT. With an efficient working of the different optical amplifiers OA1, OA2, ..., OAi, ..., OAn simular to the optical amplifier OAi in the optical amplifier splitter arrangement OAS and an appropriate access protocol that assures continuous upstream transmission for the outgoing signal OUT, the outgoing optical signal OUT has no longer a bursty character like the information signals IN1, IN2, ..., INi, ..., INn have. In this way, a fast gain setting optical amplifier is no longer required for the amplification of the optical outgoing signal OUT and a standard optical amplifiers can be used.

While the principles of the invention have been described above in connection with specific apparatus, it is to be clearly understood that this description is made only by way of example and not as a limitation on the scope of the invention.

Claims

1. Optical amplifier splitter arrangement (OAS) in a tree-like optical network (APON) consisting of the cascade connection of dedicated branches (B1, B2,..., Bi, ..., Bn), of said arrangement (OAS) and of a common branch, said arrangement being coupled between a plurality of optical network users (ONU1, ONU2, ..., ONUi, ..., ONUn) and an optical line terminator (OLT) via said dedicated branches and said common branch respectively, said network enabling upstream transmission of information signals (IN1, IN2, ..., INi, ...,INn) from said optical network users (ONU1, ONU2, ..., ONUi, ..., ONUn) to said optical line terminator (OLT), characterized in that said optical amplifier splitter arrangement (OAS) includes for each branch (Bi) of said dedicated branches (B1,B2, ..., Bi, ..., Bn) :

   - an optical amplifier (OAi) to amplify a respective one (INi) of said information signals (IN1, IN2,..., INi, ...,INn) transmitted over said branch (Bi), with a gain value (Gi) and to thereby generate an amplified information signal (A-INi) with a predetermined power level;
   - an optical switch on/off (SW ON/OFFi) coupled between said optical amplifier (OAi) and an optical splitter (OS) which is included in said arrangement to combine all amplified information signals (A-IN1, A-IN2, ..., A-INi, ..., A-INn) simular to said amplified information signal (A-INi) according to a multiple access technique and to thereby generate an outgoing optical signal (OUT) for application to said optical line terminator (OLT), said optical switch on/off (SW ON/OFFi) being provided to pass said amplified information signal (A-INi) when it is present and to interrupt said branch (Bi) when it is not present.

2. Optical amplifier splitter arrangement (OAS) according to claim 1 characterized in that said arrangement (OAS) also includes for each said branch (Bi) a control means (CTRLi) coupled to said optical amplifier (OAi) and to said optical switch on/off (SW ON/OFFi), said control means (CTRLi) being adapted to control said gain value

(Gi) by means of a first electrical control signal (CTRL-Ai) composed of gain setting data (GSi) and gain tuning data (GTi), and to control said switch on/off (SW ON/OFFi) by means of a second electrical control signal (CTRL-Bi).

3. Optical amplifier splitter arrangement (OAS) according to claim 2 characterized in, that for each said branch (Bi), said control means (CTRLi) further includes power detection means provided to detect whether said one information signal (INi) is present or is not present and to determine said second electrical control signal (CTRL-Bi) as a result thereof.

4. Optical amplifier splitter arrangement (OAS) according to claim 2 characterized in that said optical splitter (OS) is provided to combine said amplified information signals (A-IN1, A-IN2, ..., A-INi, ..., A-INn) according to a time division multiple access (TDMA) technique, and in that said arrangement (OAS) also includes an optical network terminator (NTOAM) for performing operation and maintenance functions and which is coupled to said optical line terminator (OLT) and said control means (CTRLi), said optical network terminator (NTOAM) being included to capture special grant information out of downstream signals sent from said optical line terminator (OLT) to said optical network users (ONU1, ONU2, ..., ONUi, ..., ONUn) and to apply said special grant information to said control means (CTRLi) to thereby enable said control means (CTRLi) to determine whether said information signal (INi) will be present or not present within a predetermined time interval and to determine said second electrical control signal (CTRL-Bi) as a result thereof.

5. Optical amplifier splitter arrangement (OAS) according to claim 2 characterized in that for each said branch (Bi) said control means (CTRLi) further includes power measuring means provided to measure the power of said one information signal (INi) and to determine said gain setting data (GSi) based thereon.

6. Optical amplifier splitter arrangement (OAS) according to claim 2 characterized in that, for each said branch (Bi), said control means (CTRLi) further includes power measuring means provided to measure the power of said amplified information signal (A-INi) and to determine said gain tuning data (GTi) based thereon.

7. Optical amplifier splitter arrangement (OAS) according to claim 2 characterized in that, for each said branch (Bi), said control means (CTRLi) further includes power measuring means provided to measure the power of said amplified information signal (A-INi) and to provide a value of measured power of said amplified information signal (A-INi) and further includes memory means to memorize said value, said value being used to determine said gain tuning data (GTi) for a following transmitted information signal (INi).

8. Optical amplifier splitter arrangement (OAS) according to claim 2 characterized in that said arrangement (OAS) also includes a power level unit (P-opt) coupled between a control output of said optical splitter (OS) and said control means (CTRLi) associated with each branch (Bi), said power level unit being (P-opt) provided to measure the power level of said outgoing optical signal (OUT) and to supply as a result thereof electrical power level data (P-OUT) to said control means (CTRLi) to thereby enable said control means (CTRLi) to determine said gain tuning data (GTi) when said information signal (A-INi) is present.

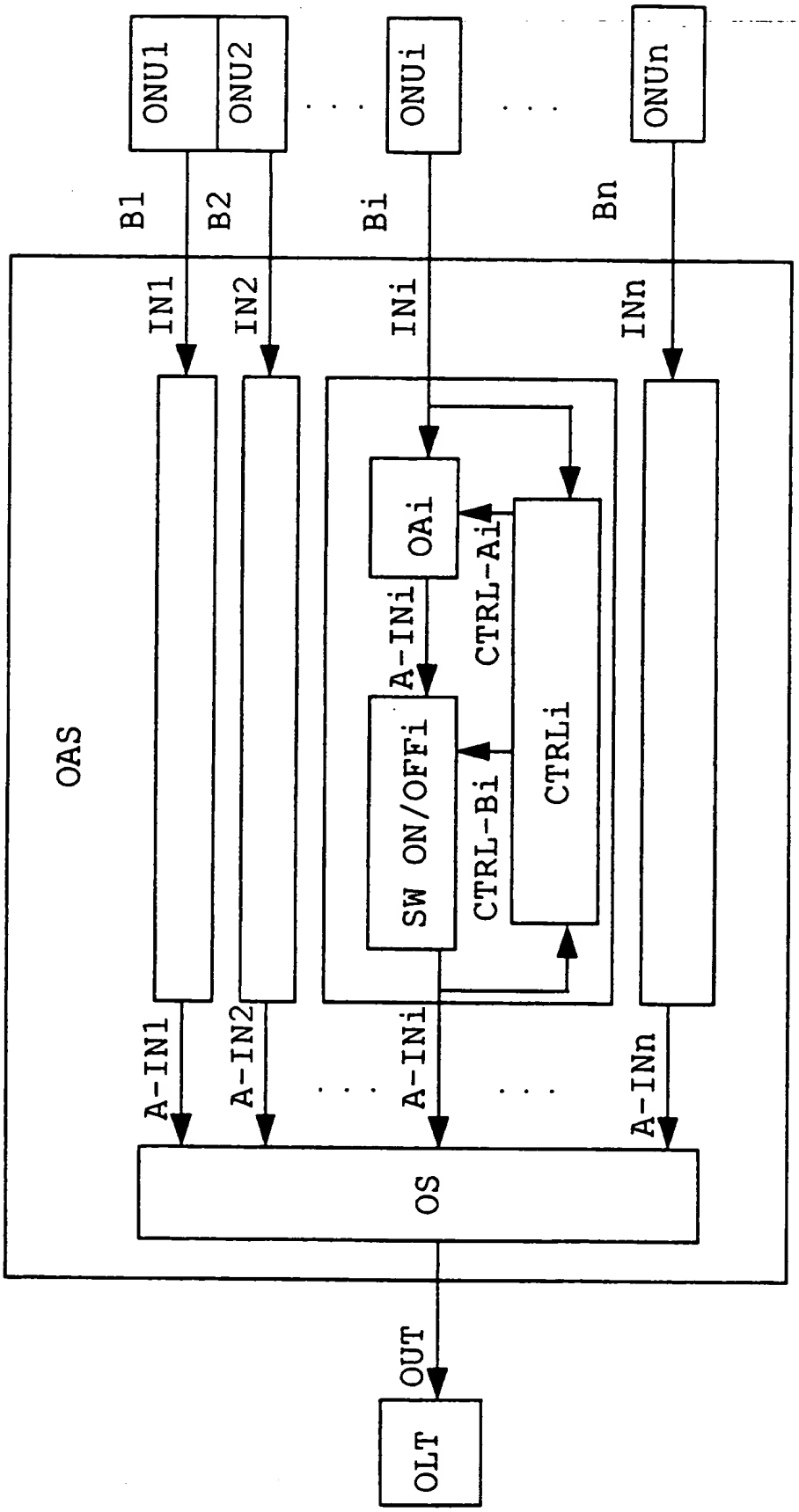
9. Optical amplifier splitter arrangement (OAS) according to claim 1 characterized in that said optical splitter (OS) and all optical switches on/off (SW ON/OFF1, SW ON/OFF2, ..., SW ON/OFFi, ..., SW ON/OFFn) simular to said optical switch on/off (SW ON/OFFi) are integrated in an optical switch (OSW).

10. A method used in a tree-like optical network (APON) to perform upstream transmission of information signals (IN1, IN2,..., INi, ..., INn) from a plurality of optical network users (ONU1, ONU2, ..., ONUi, ..., ONUn) to an optical line terminator (OLT) via dedicated branches (B1, B2,..., Bi, ..., Bn) and a common branch respectively, characterized in that said method for each one (INi) of said information signals (IN1, IN2, ..., INi, ..., INn) comprises the steps of :

    a. amplifying said information signal (INi) and thereby generating an amplified information signal (A-INi);
    b. passing said amplified information signal (A-INi) when said information signal (INi) is present and interrupting said branch (Bi) when said information signal (INi) is not present;

and further includes the step of :

    c. combining all amplified information signals (A-IN1, A-IN2, ..., A-INi, ..., A-INn) simular to said amplified information signal (A-INi) according to a multiple access technique thereby generating an outgoing optical signal (OUT) which is transmitted to said optical line terminator (OLT).



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EUROPEAN SEARCH REPORT

Application Number
EP 95 20 2553

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
Y	EP-A-0 499 065 (STANDARD ELEKTRIK LORENZ) * column 7, line 41 - line 45 * * figure 1 *	1-3,5,6, 10	H04B10/00 H04B10/17 H04B10/207
Y	EP-A-0 534 433 (NEC) * column 1, line 20 - line 22 * * column 6, line 16 - line 34 * * column 7, line 5 - line 27 * * column 7, line 55 - column 8, line 2 * * figures 2,3,5 *	1-3,5,6, 10	
A	EP-A-0 506 163 (PIRELLI) * column 4, line 46 - column 5, line 3 * * column 6, line 56 - column 7, line 3 *	1-10	
A	EP-A-0 425 871 (BROADBAND TECHNOLOGIES) * column 2, line 17 - line 35 * * figure 1 *	4,10	
			TECHNICAL FIELDS SEARCHED (Int.Cl.6) H04B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	20 February 1996	Williams, M.I.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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